Chapter 1

Introduction

1.1 The Need for Aviation System Capacity Improvement

In 1991, 23 airports each exceeded 20,000 hours of annual aircraft flight delays. With an average airline operating cost of about $1,600 per hour of delay,[1] this means that each of these 23 airports incurred a minimum of $32 million dollars of delay. By 2002, the number of airports that will exceed 20,000 hours of annual delay is projected to grow from 23 to 33, unless capacity improvements are made.

In 1991, 23 airports each exceeded 20,000 hours of annual aircraft flight delays.

The purpose of this plan is to identify and facilitate actions that can be taken by both the public and private sectors to prevent the projected growth in delays. These actions include:

By 2002, the number of airports that will exceed 20,000 hours of annual delay is projected to grow from 23 to 33, unless capacity improvements are made.

- Airport Development
- New Air Traffic Control Procedures
- Airspace Development
- New Technology
- Marketplace Solutions

Flights exceeding 15 minutes of delay decreased 24 percent in 1991 compared to 1990. The forecast for 33 airports exceeding 20,000 hours of annual aircraft flight delays in 2002 is seven less than the 40 airports predicted in last year's forecast. These and other delay statistics for 1991 show a reduction in almost every category of delay over 1990. This reduction reflects the overall decline in air travel that resulted from the Persian Gulf War, a slower recovery than expected from the economic recession, and a more moderate level of growth in air traffic as the economy struggled to recover.

1. This average figure equates approximately to the cost for large air carrier aircraft (<300,000 lbs.) and small jets ($1,607 per hour). Heavy aircraft (>300,000 lbs) cost approximately $4,575 per hour of delay. Single-engine and twin-engine aircraft under 12,500 lbs. cost $42 and $124 per hour of delay respectively.

Yet, even with overall demand throughout the system temporarily reduced, demand at the most congested airports remained high. The same 23 airports experienced over 20,000 hours of annual aircraft flight delays in 1991 as in 1990. As the economy recovers, the demand for air travel will grow. As the number of aircraft operations increases to meet that demand, the level of delay will increase concurrently unless improvements are made to system capacity.

Resolving the problem of delay will require an integrated approach that develops capacity improvements throughout the aviation system, while at the same time maintaining or improving the current level of aviation safety. These capacity improvements will include not only airport development itself, but also development of new air traffic control procedures, improvements in terminal and en route airspace planning, and implementation of new technologies. Each of these topics will be discussed in turn in subsequent chapters.

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Although the current forecasts continue to project serious delays in the absence of capacity improvements, the message contained in the following pages is positive. For example, much is currently being done to improve capacity and reduce delays through new construction projects at airports and recent enhancements in Air Traffic Control (ATC) procedures. Airspace capacity design projects are being undertaken to study the terminal airspace associated with delay-impacted airports across the country. In addition, there are many emerging technologies in the areas of surveillance, communications, and navigation that will further improve the efficiency of new and existing runways and of terminal and en route airspace.

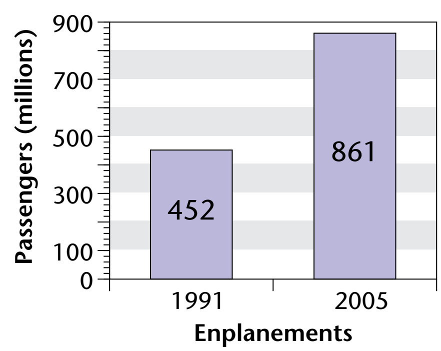
1.2 Aviation System Capacity Plan

The *Aviation System Capacity Plan* (ASCP) is an important part of Federal Aviation Administration (FAA) and Department of Transportation efforts to improve the Nation's transportation system. The Secretary of Transportation's *National Transportation Policy* (NTP) describes the enormity of the Nation's transportation infrastructure needs and sets as a major theme the need to maintain and expand the national transportation system. The *Federal Aviation Administration Strategic Plan*, based on the NTP, provides the long-term goals and objectives that the FAA is working towards. The ASCP supports the key strategic issue of improving capacity and access.

The *Aviation System Capacity Plan* is also linked to other FAA plans. In particular, the ASCP addresses requirements for research, for facilities and equipment, and for airport improvements that can be funded from the FAA's *Airport Improvement Program* (AIP). Each of these areas is addressed in a major FAA plan, and the ASCP generates projects for each of those plans. *The Research, Engineering, and Development (*RE&D*) Plan* is used to determine which systems and technologies the FAA should use to accomplish agency goals and objectives. The RE&D Plan includes the research needed to validate the new instrument approach procedures detailed in Chapter 3. The *Capital Investment Plan* (CIP) provides a framework for investment in the facilities and equipment needed to improve the National Airspace System (NAS). The CIP funds the technological improvements described in Chapter 5. The *National Plan of Integrated Airport Systems* (NPIAS) presents airport improvement projects nationwide that are eligible for AIP funding. Among these are projects, detailed in Chapter 2, to build new airports and to improve existing airports to increase capacity and safety.

The *Aviation System Capacity Plan* identifies the causes of delay and quantifies its magnitude for the top 100 airports in the U.S. The purpose of the plan is to catalogue and summarize programs that have the potential to enhance capacity and reduce delay. Within the plan, these programs have been organized into broadly related categories which, in turn, parallel chapter development: Airport Development, New Air Traffic Control Procedures, Airspace Development, New Technology, and Marketplace Solutions.

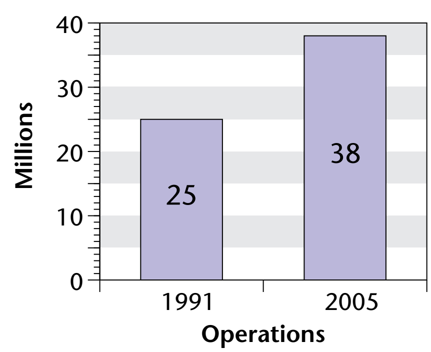
The top 100 airports accounted for 90 percent of the 452 million domestic passengers who enplaned nationally in 1991.



1.3 Level of Aviation Activity

This plan concentrates on the top 100 airports in the U.S., shown in Figure 1-1, as measured by 1991 passenger enplanements. The top 100 airports[2] accounted for 90 percent of the 452 million domestic passengers who enplaned nationally in 1991.

In 2005, 861 million domestic and international passengers are forecast to enplane at these airports.[3] This represents a projected growth in enplanements of 90 percent over the 15 year period of the forecast, for an average annual growth of about 6 percent.



2. The top 100 airports were chosen based on CY91 passenger enplanements as listed in preliminary data intended for the annual report, *Airport Activity Statistics of Certificated Route Air Carriers*. A national map of the 100 airports is pictured in Figure 1-1, and recent operations and enplanement data are provided in Table A-1 of Appendix A.
3. Based on FAA's *Terminal Area Forecast FY1992–2005*, FAA-APO-92-5, July 1992. FY90 enplanement data, a 15 year forecast, and percentage growth that the forecast represents are shown in Table A-2 (Appendix A).

In 1991, approximately 25 million aircraft operations occurred at the top 100 airports. By 2005, operations are forecast to grow to nearly 38 million at these same airports; a projected growth in operations of 52 percent.[4]

1.3.1 Activity Statistics at Top 100 Airports

Aircraft operations increased from FY90 to FY91 at 26 of the top 100 airports.

For the top 100 airports, enplanements increased at only 36 airports from Calendar Year (CY)90 to CY91 and decreased at the remaining 64.[5] Aircraft operations increased from Fiscal Year (FY)90 to FY91 at only 26 of the top 100 airports.[6]

1.3.2 Traffic Volumes in Air Route Traffic Control Centers (ARTCCs)

IFR operations decreased slightly at all 20 of the CONUS ARTCCs over 1990.

Air traffic volume statistics for 1991 showed that instrument flight rules (IFR) operations decreased slightly at all 20 of the Continental United States (CONUS) Air Route Traffic Control Centers (ARTCCs) over 1990.[7] This downturn in operations throughout the aviation system reflects the significant decline in air travel in 1991 that resulted from the Persian Gulf War and the U.S. economic recession.

4. Table A-3 (Appendix A), based on FAA's *Terminal Area Forecast FY1992–2005*, FAA-APO-92-5, July 1992, shows FY90 aircraft operations, a 15 year forecast, and percentage growth by airport.
5. See Table A-4 (Appendix A) for a ranking by percentage growth in enplanements at the top 100 airports.
6. See Table A-5 (Appendix A) for a ranking by percentage growth in operations at the top 100 airports.
7. Figure 1-2 provides a map of the 20 CONUS ARTCCs. Figure 1-3 provides a comparison of the number of operations during FY90 versus the number of operations in FY91 at each of the 20 ARTCCs in CONUS. Figure 1-4 shows FY91 operations and a forecast for 2005.

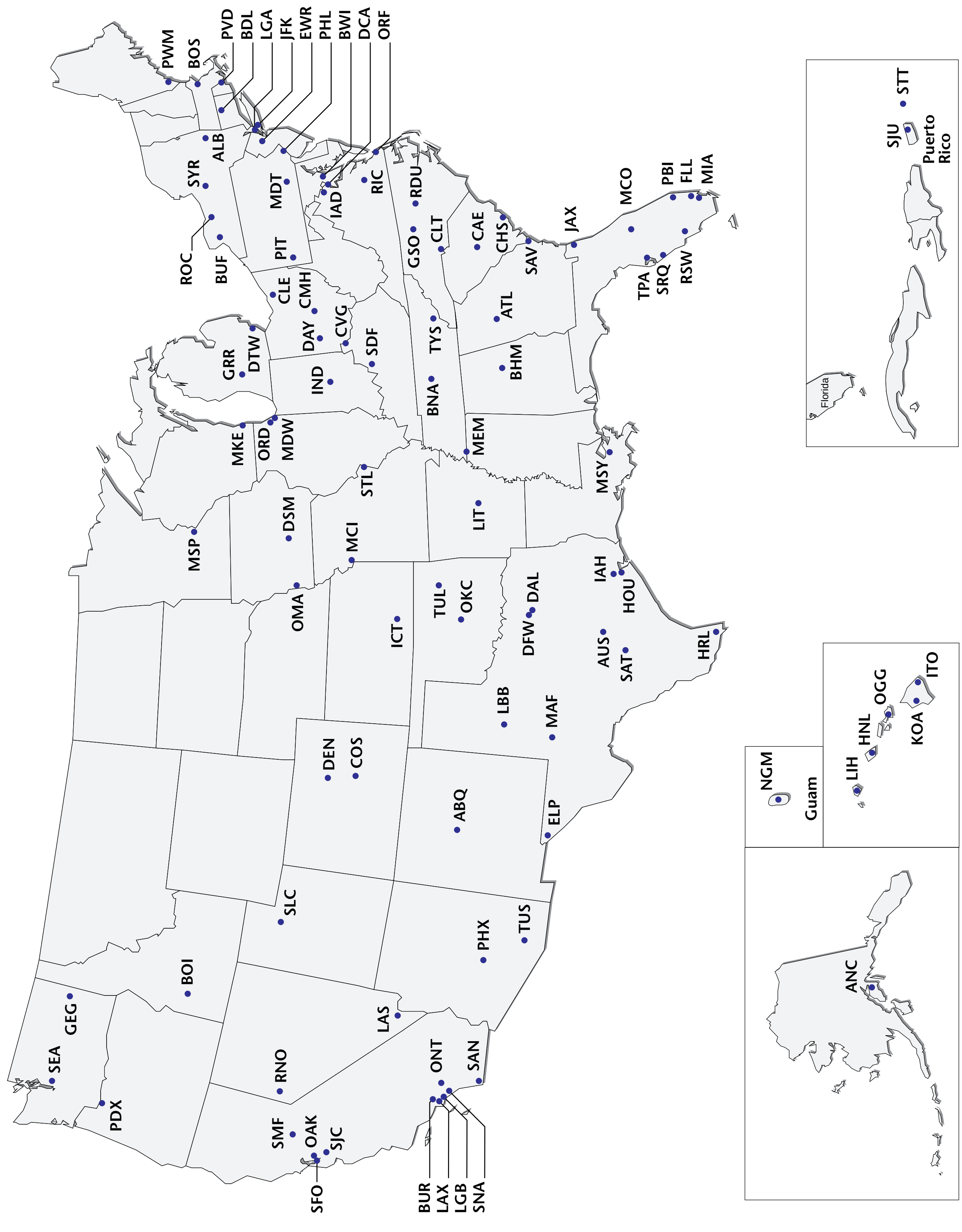


Figure 1-1. The Top 100 Airports by 1991 Enplanements
Source: Airport Activity Statistics of Certificated Air Route Carriers, 1990

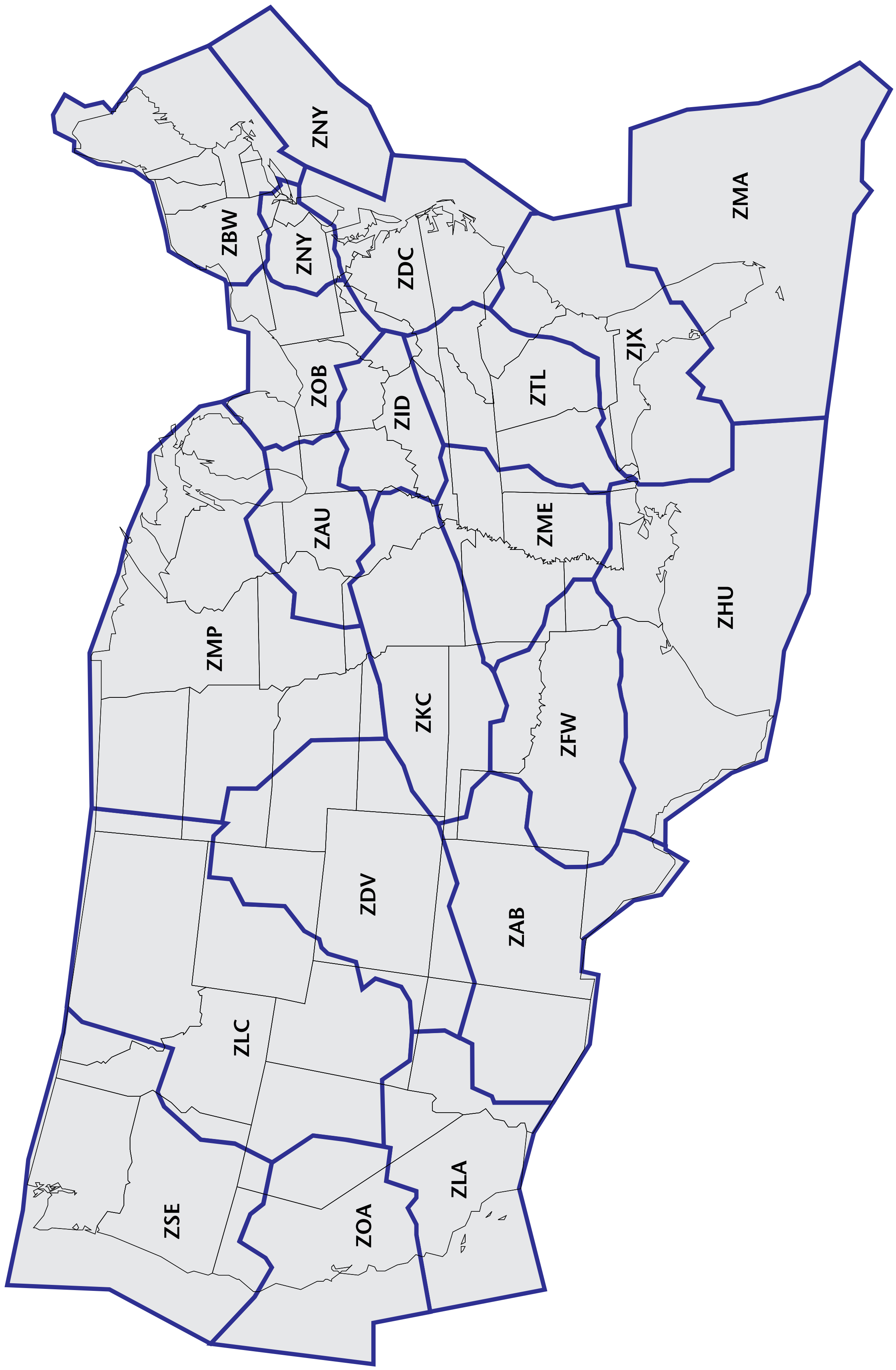


Figure 1-2. The 20 Continental U.S. Air Route Traffic Control Centers

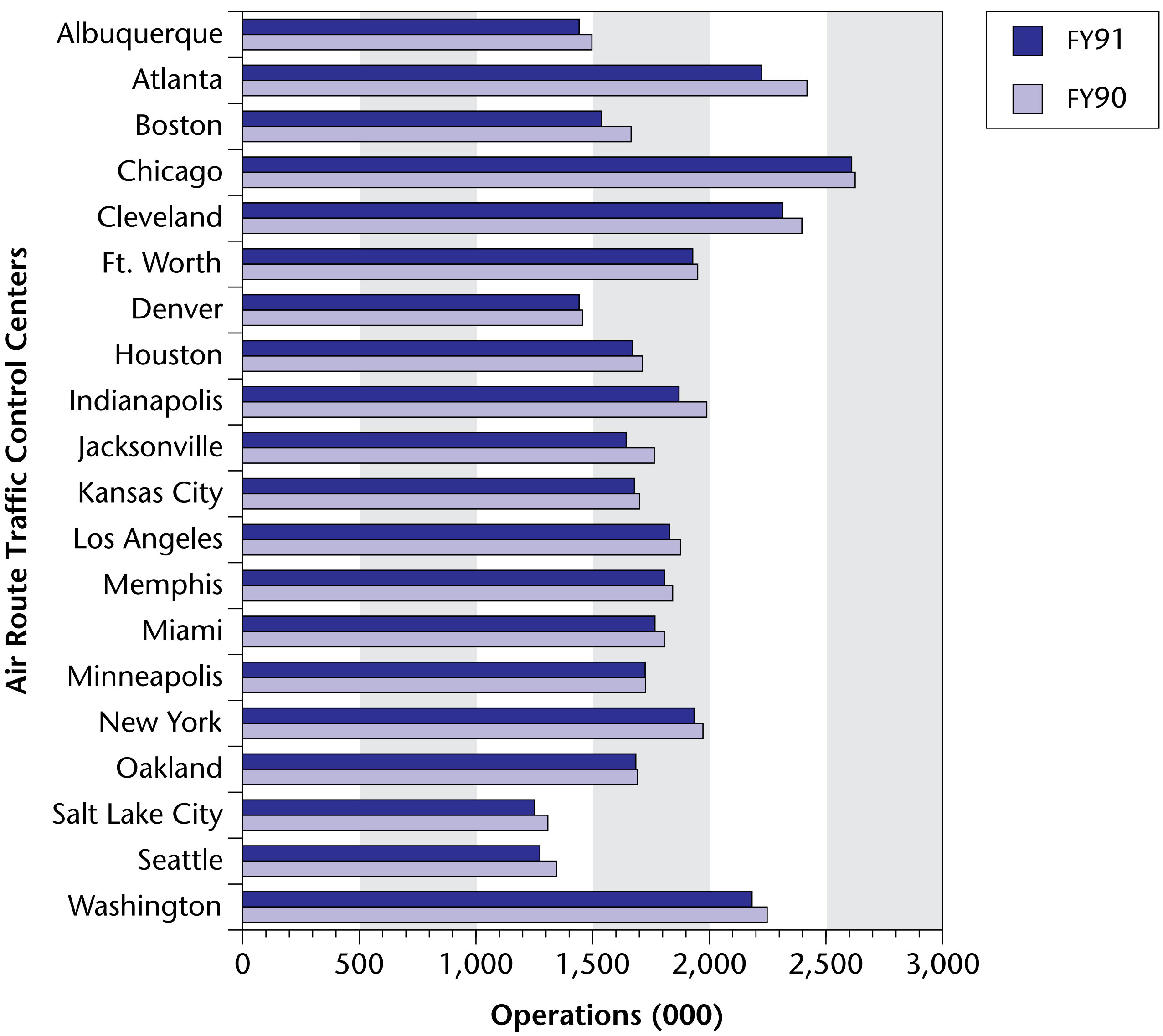


Figure 1-3. Operations at Air Route Traffic Control Centers
Source: APO Forecast of IFR Aircraft Handled by ARTCC, FY92-FY05, June 1992

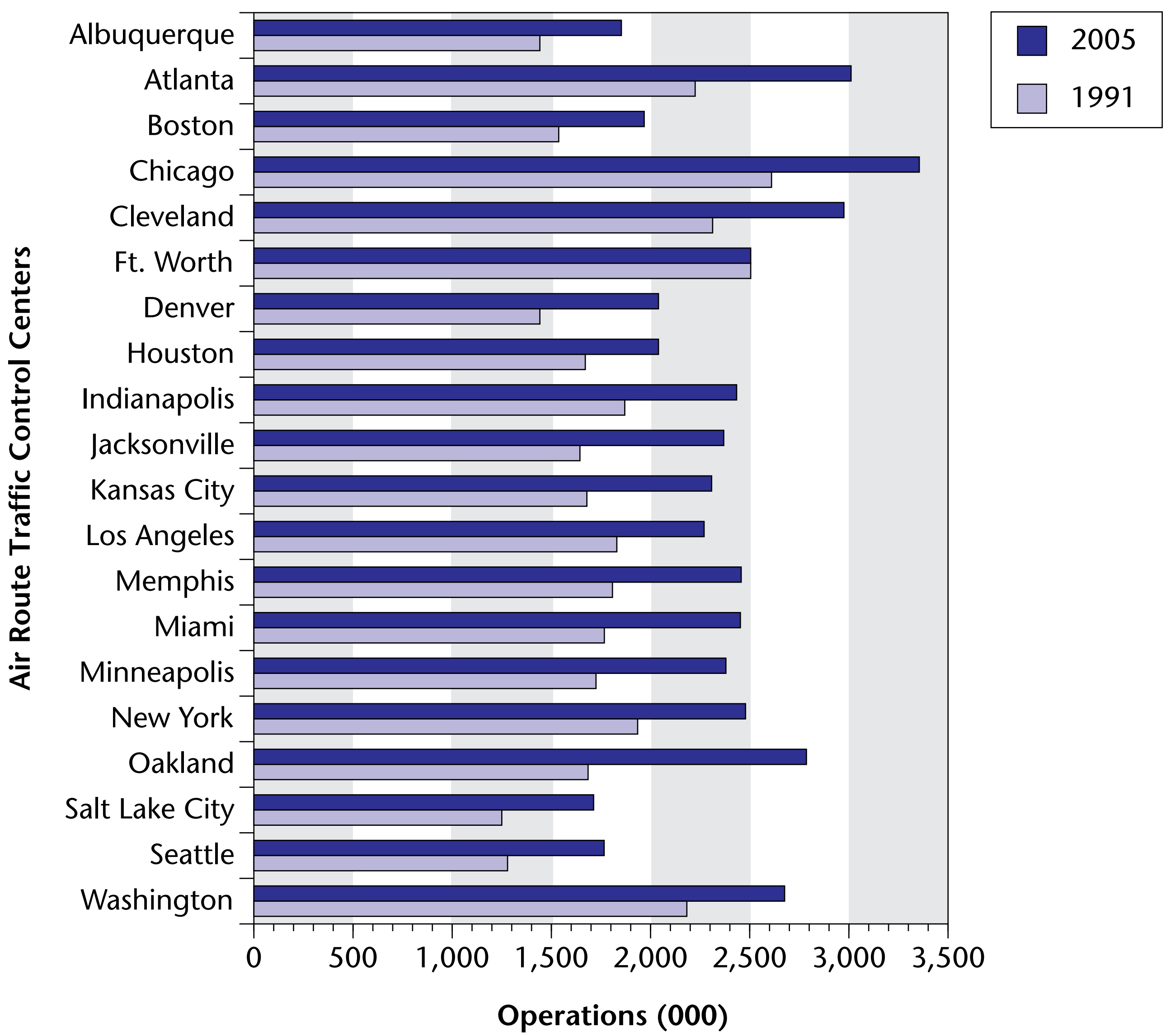


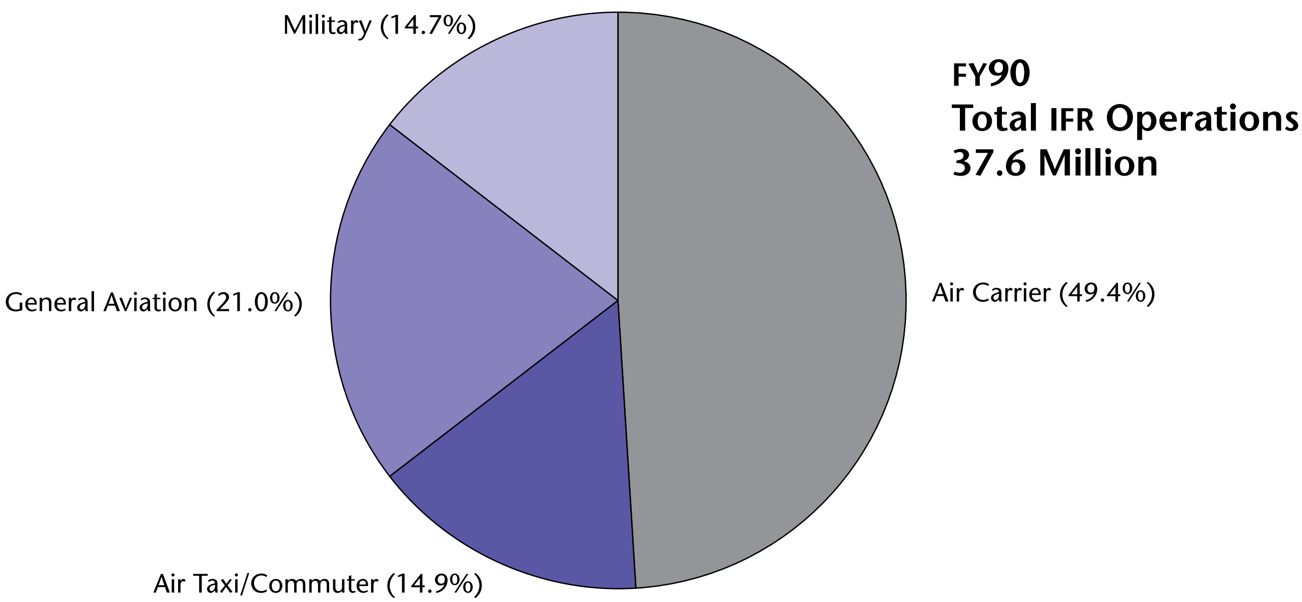
Figure 1-4. Air Route Traffic Control Center Forecasts
Source: APO Forecast of IFR Aircraft Handled by ARTCC, FY92-FY05, June 1992

In 1991, the number of aircraft flying under instrument flight rules handled by ARTCCs decreased by 3.2 percent compared to 1990, from 37.6 down to 36.4 million operations. Commercial aircraft handled at the centers decreased by 1.4 percent, compared with a decline of 6.3 percent in non-commercial aircraft handled. Table 1-1 shows the rate of decline for each user group from 1990 to 1991. Figure 1-5 compares a breakdown by user group of the traffic handled by the centers in 1990 and 1991.

In 1991, the number of aircraft flying under instrument flight rules handled by ARTCCs decreased by 3.2 percent compared to 1990, down to 36.4 million operations.

Table1-1. Rate of Decline by User Group in Traffic Handled by Air Route Traffic Control Centers FY90 to FY91

User Group	Rate of Decline FY90 to FY91
Air Carrier	1.4%
Air Taxi/Commuter	1.2%
General Aviation	6.8%
Military	5.5%



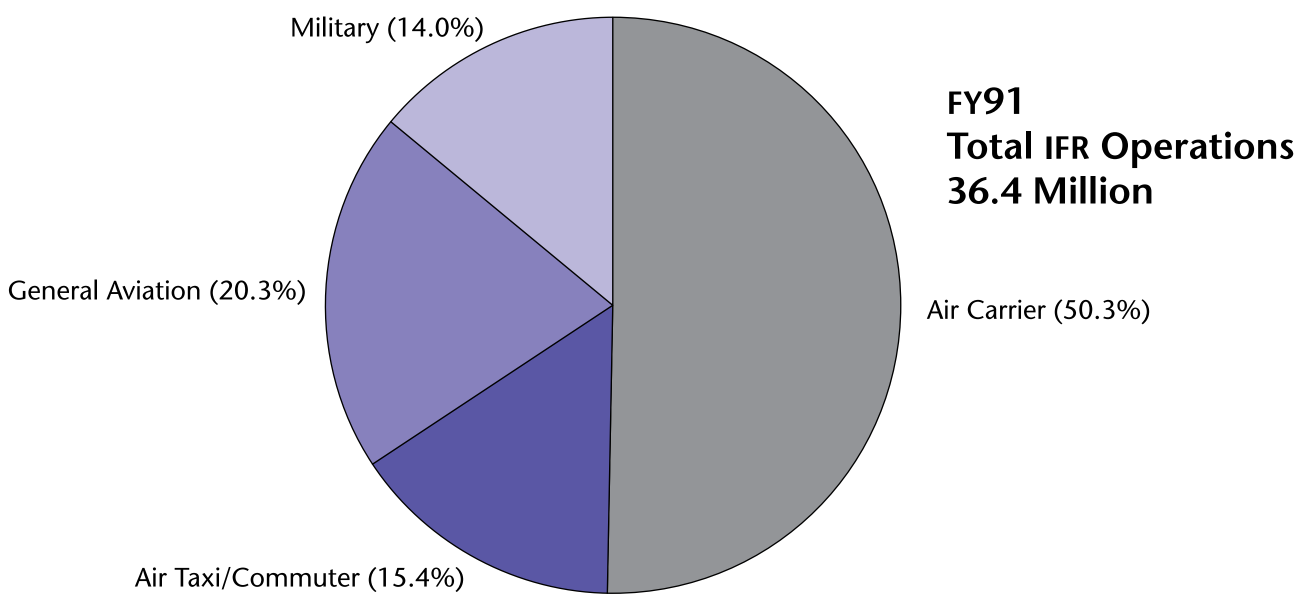


Figure 1-5. Traffic Handled by ARTCCs, FY90 and FY91

Aircraft operations at the centers are expected to grow at an average rate of 2.3 percent a year between 1991 and 2005. In absolute numbers, center operations are forecast to increase from 36.4 million aircraft handled in 1991 to 48.2 million in 2005. Table 1-2 shows the projected annual growth rates for each user group over the forecast period. In 1991, 50.3 percent of the traffic handled at centers were air carrier flights. This proportion is expected to increase only slightly to about 51.3 percent in 2005. Figure 1-6 compares a breakdown by user group of the traffic handled by the centers in 1991 and projected for 2005.

Center operations are forecast to increase from 36.4 million aircraft handled in 1991 to 48.2 million in 2005.

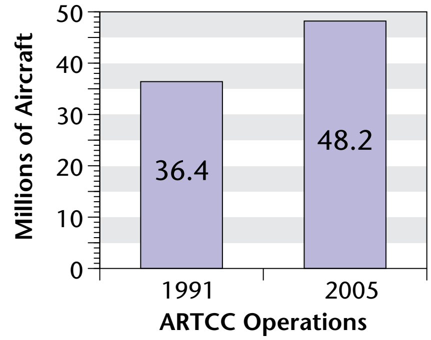


Table1-2. Projected Annual Growth Rate by User Group in Traffic Handled by Air Route Traffic Control Centers FY90 to FY05

User Group	Rate of Growth FY91 to FY05
Air Carrier	2.5%
Air Taxi/Commuter	3.8%
General Aviation	1.9%
Military	>1%

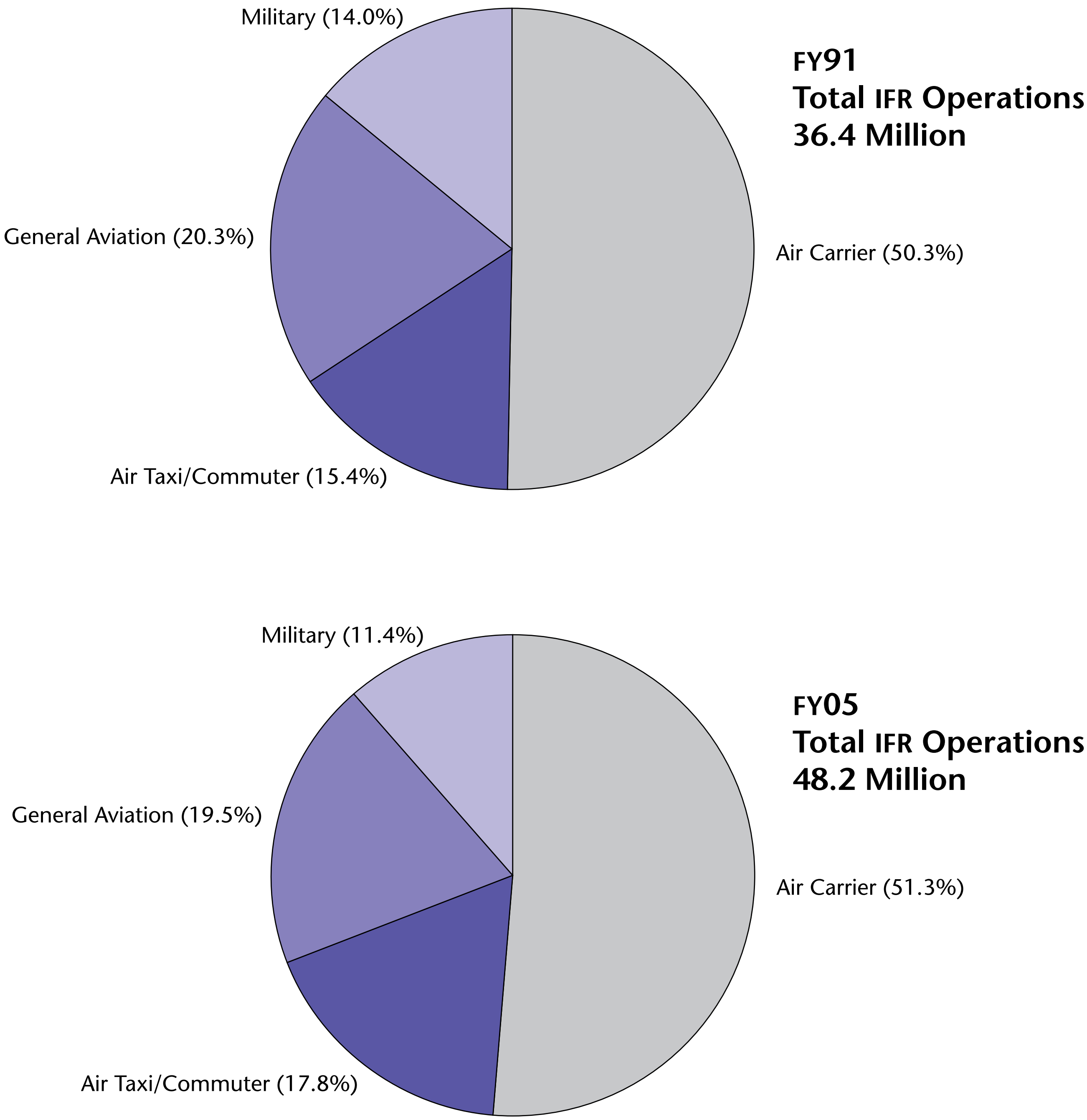
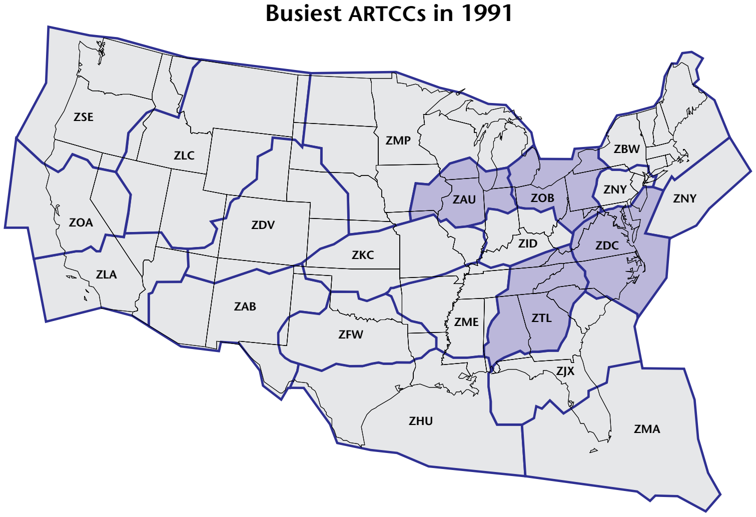


Figure 1-6. Traffic Handled by ARTCCs, FY91 and Forecast FY05

The busiest Federal Aviation Administration (FAA) ARTCCs in 1991 were: Chicago, Cleveland, Atlanta, and Washington. Forecasts for 2005 indicate a change in ranking of the busiest ARTCCs to: Chicago, Atlanta, Cleveland, and Oakland.

Chicago Center, the busiest FAA ARTCC in 1991, handling 2.6 million aircraft, is projected to handle 3.4 million aircraft by the year 2005. The centers with the highest average annual growth rates are Oakland and Jacksonville, which are projected to grow by 4.1 and 2.8 percent respectively. The relatively high growth at these two centers reflects the projected high growth of domestic traffic demand in the West and South. Oakland Center is forecast to experience the largest absolute growth, from 1.7 million aircraft operations in 1991 to 2.8 million in the year 2005. This reflects the continuing development and strong projected growth on trans-Pacific routes.

Busiest ARTCCs in 1991



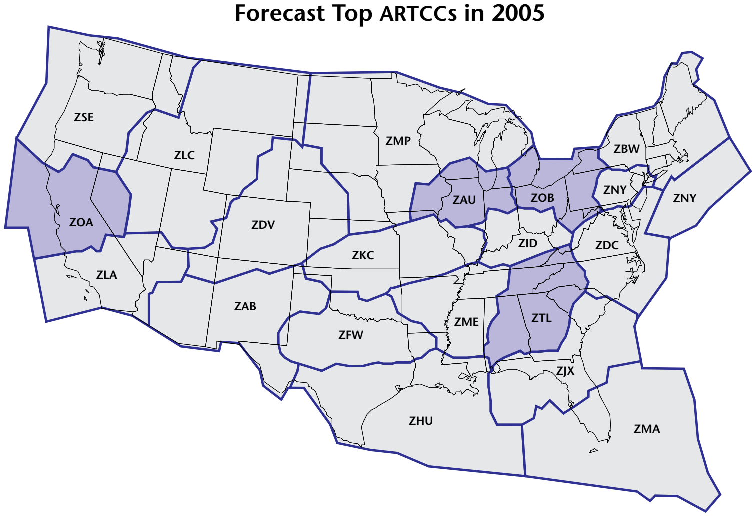
The busiest FAA ARTCCs in 1991 were:

Chicago,
Cleveland,
Atlanta, and
Washington.

Forecasts for 2005 indicate a change in ranking of the busiest ARTCCs to:

Chicago,
Atlanta,
Cleveland, and
Oakland.

Forecast Top ARTCCs in 2005



1.4 Delay [8]

1.4.1 Sources of Delay Data

Delay can be thought of as another system performance parameter, as an indicator that capacity is perhaps being reached and even exceeded. Currently, the FAA gathers delay data from two different sources. The first is through the Air Traffic Operations Management System (ATOMS), in which FAA personnel record aircraft that are delayed more than 15 minutes by cause, (weather, terminal volume, center volume, closed runways or taxiways, and NAS equipment interruptions). Aircraft that are delayed by less than 15 minutes are not recorded.

The second source of delay data is through the Airline Service Quality Performance (ASQP) data, which is collected, in general, from airlines with one percent or more of the total domestic scheduled service passenger revenue[9] and represents delay by phase of flight (gate-hold, taxi-out, airborne, or taxi-in delays).[10] Actual departure time, flight duration, and arrival time are reported along with the differences between these and the equivalent data published in the *Official Airline Guide* (OAG) and entered in the Computer Reservation System (CRS). ASQP delays range from 0 minutes to greater than 15 minutes. In the discussion that follows, “delay by cause” refers to ATOMS data, and “delay by phase of flight” refers to ASQP data.

1.4.2 Delay by Cause

Flight delays exceeding 15 minutes, as recorded by ATOMS, were experienced on 297,758 flights in 1991, a decrease of 24.2 percent over 1990. Weather was attributed as the primary cause of 66 percent of operations delayed by 15 minutes or more in 1991, up from 53 percent in 1990. Terminal air traffic volume accounted for 27 percent of delays greater than 15 minutes, down from 36 percent in 1990. Table 1-3 provides a history of this breakdown of delays greater than 15 minutes by primary cause, and Figure 1-7 compares

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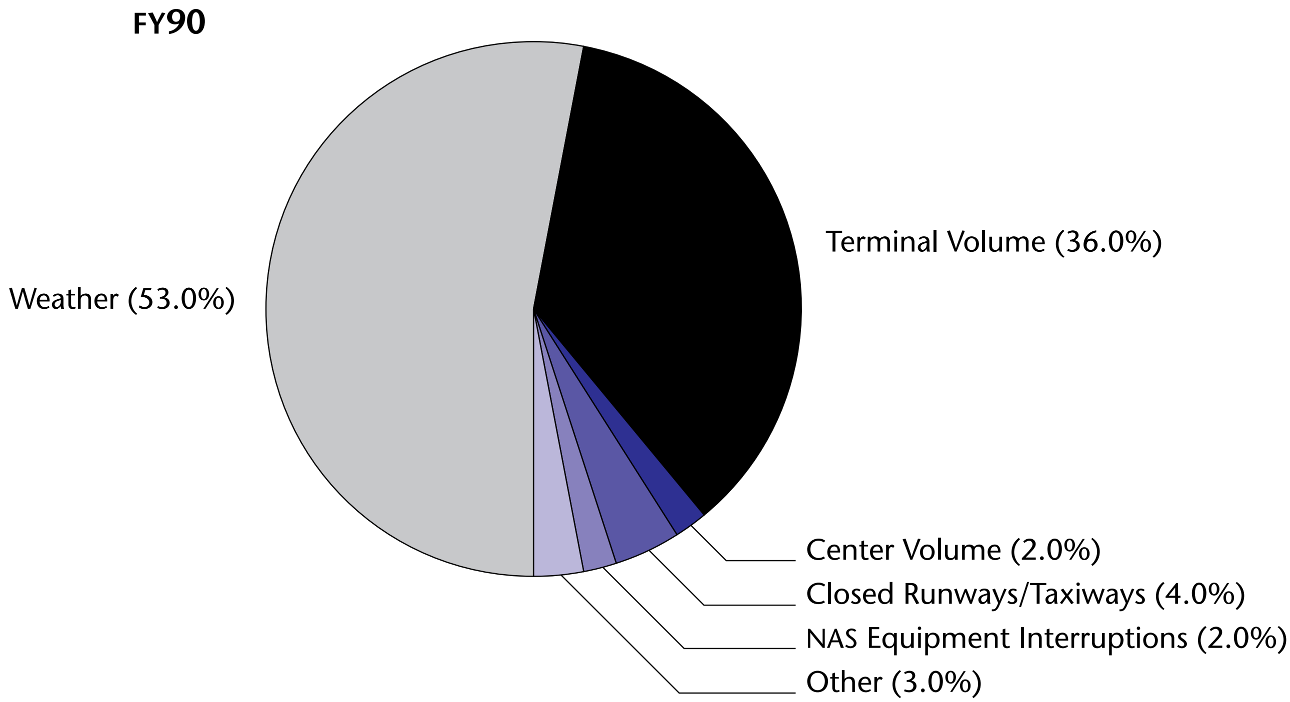
8. Although no existing delay reporting system is fully comprehensive, this Plan aims to identify problem areas through available data, such as the following delay information and the previously mentioned aviation activity statistics.
9. Airlines reporting Airline Service Quality Performance (ASQP) data as of July 1, 1991 include: Air West, Alaska, American, Continental, Delta, Midway, Northwest, Pan American, Southwest, TWA, United, and USAir.
10. See footnote on page 1-18.

the primary causes of this delay for FY90 and FY91. With the exception of the split between terminal and center volume delays, the basic distribution of delay by cause has remained fairly consistent over the past seven years.

More than half of all delays are attributed to adverse weather conditions. These delays are largely the result of instrument approach procedures that are much more restrictive than the visual procedures in effect during better weather conditions. The FAA continues to install new and upgrade existing Instrument Landing Systems (ILSs) to support continued operations during conditions of reduced visibility. During the past few years, the FAA has developed new, capacity-enhancing approach procedures that take advantage of improving technology while maintaining the current level of safety. These new procedures, and the estimated increase in the number of operations per hour, are discussed in Chapter 3.

Table 1-3. Distribution of Delay Greater than 15 Minutes by Cause

Distribution of Delay Greater than 15 Minutes by Cause						
Cause	**1986**	**1987**	**1988**	**1989**	**1990**	**1991**
Weather	67%	67%	70%	57%	53%	66%
Terminal Volume	16%	11%	9%	29%	36%	27%
Center Volume	10%	13%	12%	8%	2%	0%
Closed Runways/Taxiways	3%	4%	5%	3%	4%	3%
NAS Equipment	3%	4%	3%	2%	2%	2%
Other	1%	1%	1%	1%	3%	2%
Total Operations Delayed (000s)	**418**	**356**	**338**	**394**	**393**	**298**
Percent Change from Previous Year	+25%	-15%	-5%	+17%	0%	-24%



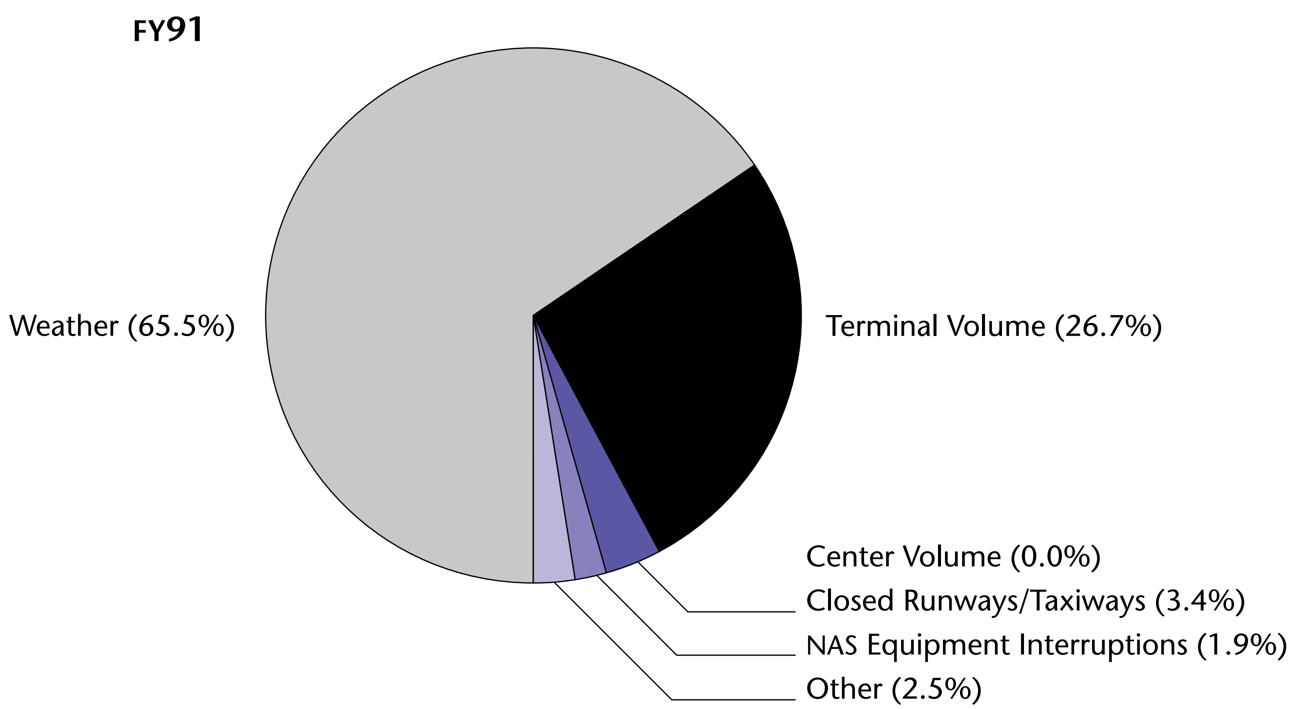


Figure 1-7. Primary Cause of Delay of 15 Minutes or More in FY90 and FY91
Source: Air Traffic Operations Management System (ATOMS) Data

1.4.3 Delay by Phase of Flight

As recorded by ASQP data, nearly 80 percent of all flights are delayed 1 to 14 minutes in taxi-in or taxi-out phases of flight, and only 5 percent of all flights have any gate-hold delay. To put this in perspective, there were approximately 6,456,000 operations in 1991. With an average airborne delay of 4.1 minutes per aircraft, this means that there was a total of over 441,000 hours of airborne delay that year, which, at an estimated $1,600 per hour, cost the airlines $706 million.

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Based on ASQP data, Table 1-4 presents the percentage of operations delayed 15 minutes or more, and Table 1-5, the average delay in minutes by phase of flight. As shown in the table, more delays occur during the taxi-out phase than any other phase.

Table 1-4. Percent of Operations Delayed

Percent of Operations Delayed 15 Minutes or More (Total ASQP System)				
Year	**1988**	**1989**	**1990**	**1991**
Percent Delayed	8.6	9.7	10.3	9.0

Table 1-5. Average Delay by Phase of Flight

Average Delay by Phase of Flight (minutes per flight)[11]				
Phase	**1988**	**1989**	**1990**	**1991**
Gate-hold	1.0	1.0	1.0	1.1
Taxi-out	6.8	7.0	7.2	6.9
Airborne	4.0	4.3	4.3	4.1
Taxi-in	2.1	2.2	2.3	2.2
Total	14.0	14.6	14.9	14.3
Mins./Op.	7.0	7.3	7.5	7.1

11. Taxi-in Delay: The difference between touchdown time and gate arrival time, minus a standard taxi-in time for a particular type of aircraft and airline at a specific airport.

    Taxi-out Delay: The difference between the time of lift-off and the time that the aircraft departed the gate, minus a standard taxi-out time established for a particular type of aircraft and airline at a specific airport.

    Airborne Delay: The difference between the time of lift-off from the origin airport and touchdown, minus the computer-generated optimum profile flight time for a particular flight, based on atmospheric conditions, aircraft loading, etc.

    Gate-hold Delay: The difference between the time that departure of an aircraft is authorized by ATC and the time that the aircraft would have left the gate area in the absence of an ATC gate-hold.

    Mins/op: Average delay in minutes per operation.

1.4.4 Identification of Delay-Problem Airports

In CY91, the number of airline flight delays in excess of 15 minutes decreased compared to 1990 at 36 of 55 major airports at which the FAA collects air traffic delay statistics. Table 1-6 lists the percentage of operations delayed 15 minutes or more over the last six years at 22 of these airports. These delays ranged from 0.2 percent of flight operations at Cleveland and Fort Lauderdale to 6.7 percent at Newark. Figure 1-8 compares the number of delays in excess of 15 minutes per 1,000 operations for 1990 and 1991 at these same 22 airports. Three of the top five airports in delays exceeding 15 minutes were in the New York area.

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1.4.5 Identification of Forecast Delay-Problem Airports

Forecasts indicate that, in the absence of capacity improvements, delays in the system will continue to grow.[12] In 1991, 23 airports each exceeded 20,000 hours of annual aircraft flight delays. Assuming no improvements in airport capacity are made, 33 airports are forecast to each exceed 20,000 hours of annual aircraft flight delays by the year 2002.[13] The current forecast for 36 delay-problem airports in 2002 is seven less than the 40 airports predicted in last year's forecast. This reflects the overall decline in air travel in 1991 as a result of the Persian Gulf War and the economic recession.

Figure 1-9 shows the airports exceeding 20,000 hours of annual aircraft delay in 1991, while Figure 1-10 shows the airports forecast to exceed 20,000 hours of annual aircraft delay in 2002, assuming there are no capacity improvements.

12. Figure 1-8. Delays Per 1,000 Operations.
13. Table 1-7. 1991 Actual and 2002 Forecast Air Carrier Delay Hours.

Table 1-6. Percentage of Operations Delayed 15 Minutes or More[14]

Airports	Percentage of Operations Delayed 15 Minutes or More						
	1985	1986	1987	1988	1989	1990	1991
New York La Guardia	9.2	8.9	6.5	5.2	9.6	8.7	6.2
Newark Int'l.	9.2	13.8	6.5	6.7	10.6	8.5	6.7
New York Kennedy	6.1	7.0	6.5	5.3	6.1	6.8	4.2
Chicago O'Hare Int'l.	4.1	5.6	4.6	5.5	10.3	6.5	4.8
San Francisco Int'l.	3.4	5.3	6.2	6.3	7.1	4.6	5.8
Atlanta Hartsfield Int'l.	6.2	6.5	6.2	3.5	2.5	4.4	2.2
Philadelphia Int'l.	0.9	2.0	3.7	2.6	2.2	3.5	1.7
Boston Logan Int'l.	6.1	7.3	4.8	3.7	2.9	3.2	3.3
Minneapolis Int'l.	2.2	3.9	0.7	1.4	0.8	3.2	0.8
St. Louis-Lambert Int'l.	4.6	4.4	1.6	2.7	2.9	2.5	3.0
Denver Stapleton Int'l.	4.6	3.2	3.7	3.7	2.7	2.9	2.9
Dallas-Ft. Worth Int'l.	1.7	2.6	2.0	1.4	2.4	3.2	3.5
Detroit Metropolitan	2.1	1.3	1.5	1.5	1.6	2.0	0.9
Houston Intercontinental	0.3	0.2	0.5	0.7	0.6	1.3	1.3
Washington National	2.0	3.2	2.3	1.5	1.0	1.0	0.5
Pittsburgh Int'l.	1.7	0.6	0.7	0.7	0.8	0.9	0.5
Los Angeles Int'l.	0.8	1.1	3.3	1.7	1.1	0.7	1.5
Miami Int'l.	0.3	0.7	0.4	0.3	0.2	0.9	2.4
Cleveland Hopkins Int'l.	0.1	0.3	0.1	0.5	0.3	0.5	0.2
Kansas City Int'l.	0.3	1.0	0.5	0.2	0.3	0.2	0.3
Ft. Lauderdale Int'l.	0.1	0.3	0.2	0.2	0.3	0.3	0.2
Las Vegas McCarran Int'l.	0.0	0.0	0.1	0.1	0.2	0.1	0.0

14. Numbers included in the table can change because of updates made to the database after publication.

Table 1-7. 1991 Actual and 2002 Forecast Air Carrier Delay Hours

Annual Aircraft Delay in Excess of 20,000 Hours					
1991		2002			
Chicago O'Hare	ORD	Chicago O'Hare	ORD	Washington National	DCA
Atlanta Hartsfield	ATL	Dallas-Ft. Worth	DFW	San Diego	SAN
Dallas-Ft. Worth	DFW	Atlanta Hartsfield	ATL	Charlotte-Douglas	CLT
Los Angeles	LAX	San Francisco	SFO	Cincinnati	CVG
Newark	EWR	Washington Dulles	IAD	Honolulu	HNL
San Francisco	SFO	Newark	EWR	Houston	IAH
Boston	BOS	St. Louis	STL	Las Vegas	LAS
New York John F. Kennedy	JFK	Los Angeles	LAX	Windsor Locks	BDL
St. Louis	STL	Phoenix	PHX	Memphis	MEM
Phoenix	PHX	New York John F. Kennedy	JFK	Baltimore Washington	BWI
Miami	MIA	Miami	MIA	Ontario	ONT
Philadelphia	PHL	Philadelphia	PHL	Nashville	BNA
Washington National	DCA	Boston	BOS	Raleigh-Durham	RDU
Pittsburgh	PIT	Detroit	DTW	Seattle-Tacoma	SEA
Detroit	DTW	Pittsburgh	PIT	Salt Lake City	SLC
Orlando	MCO	New York La Guardia	LGA		
Minneapolis	MSP	Orlando	MCO		
Charlotte	CLT	Minneapolis	MSP		
Denver Stapleton †	DEN				
Honolulu	HNL				
Houston	IAH				
Seattle-Tacoma	SEA				
New York La Guardia	LGA				

† No projection for DEN can be made under this assumption since the increased level of activity projected for Denver in 2002 cannot be handled at the existing Denver Stapelton Airport.

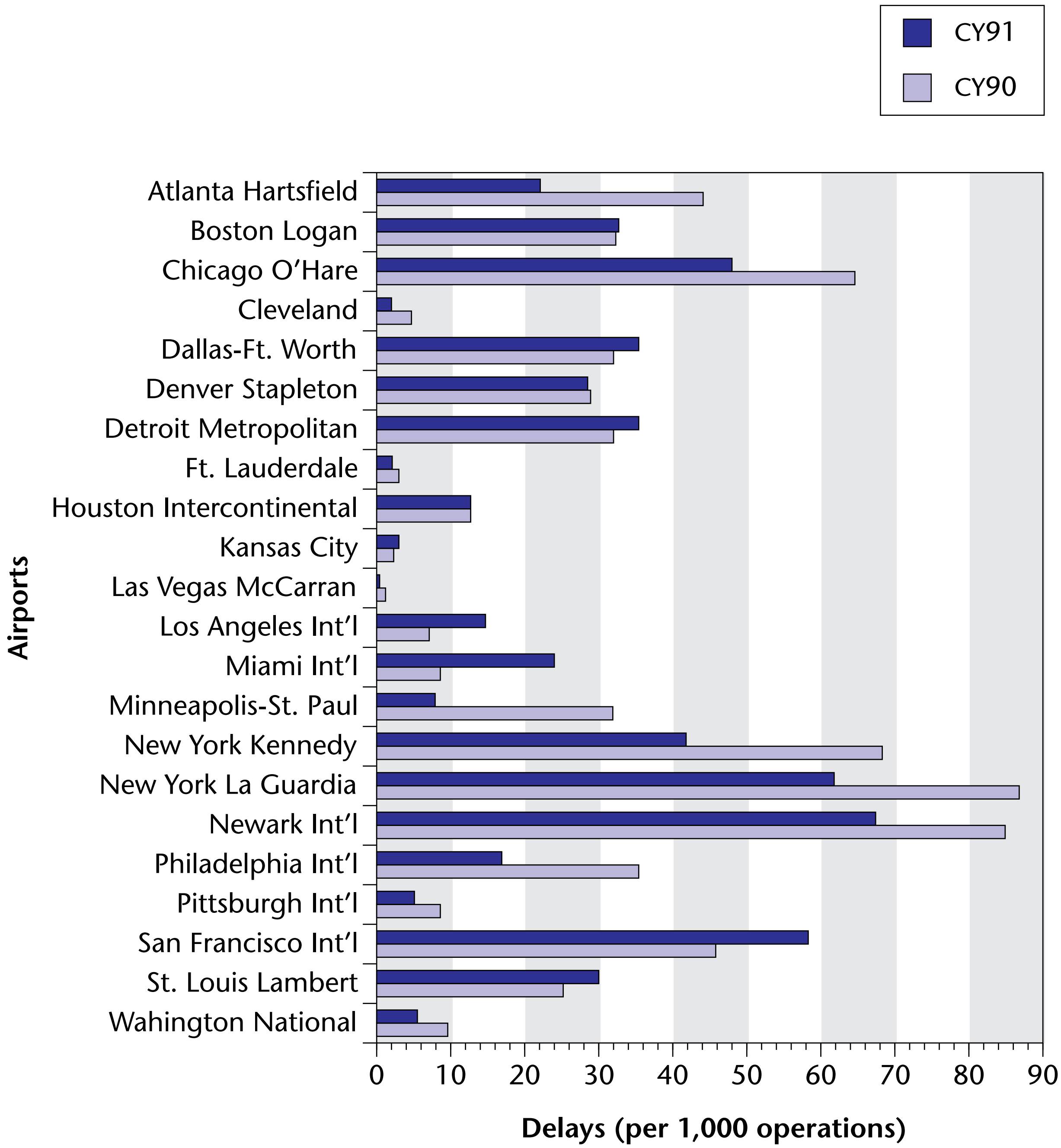

Figure 1-8. Delays Per 1,000 Operations
Source: ATOMS Data

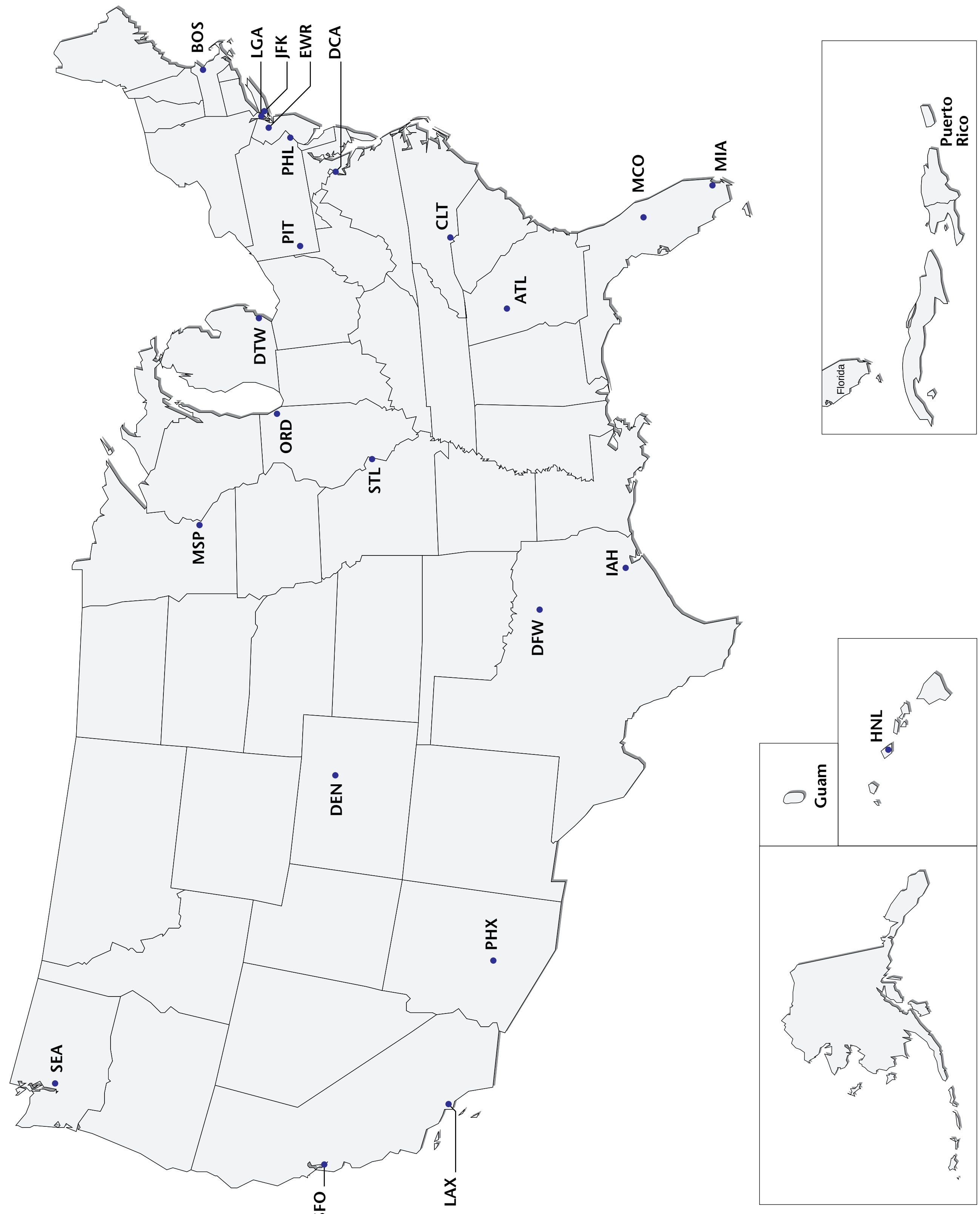

Figure 1-9. Airports Exceeding 20,000 Hours of Annual Delay in 1991
Source: FAA Office of Policy and Plans

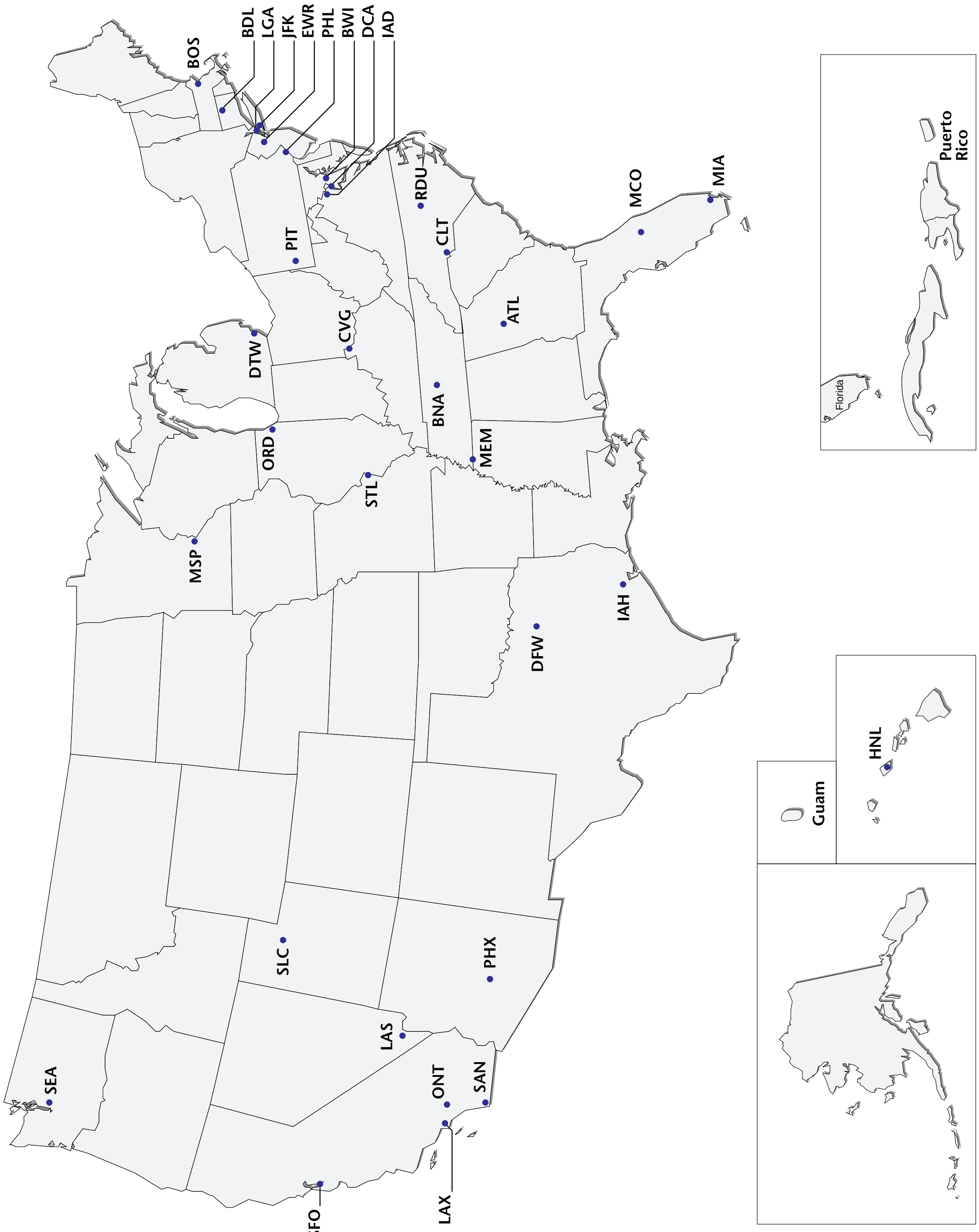

Figure 1-10. Airports Forecast to Exceed 20,000 Hours of Annual Aircraft Delay in 2002, Assuming No Capacity Improvements

Source: FAA Office of Policy and Plans